The Galactic center region and galactic outflows

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1000-yr history of the activity of Sgr A* with 6.4keV

Thermal plasma in the GC region with 6.7keV and 2.45 lines

Outflow from a galaxy

Not cover

Polarization and Compton Scatter at an XRN (→Matt-san's talk)

Hard X-ray Emission from the Galactic center region

20090703_IXO_Science_GC_Outflow_v1.key

View of the Galactic center

~300lyr

He-S-Kα (2.45keV)

Key Question:
What happend and will happen in the Galaxy where we live ?
What is the origin of the activities of the Galactic center region ?

Fe I-Kα (6.4keV)

He-Fe-Kα (6.7keV)

Fluorescence line from Molecular Cloud

Hot Plasma
T～10^8K, E~$10^{53\text{-}54}$ergs

X-ray Reflection Nebula

a high SN rate

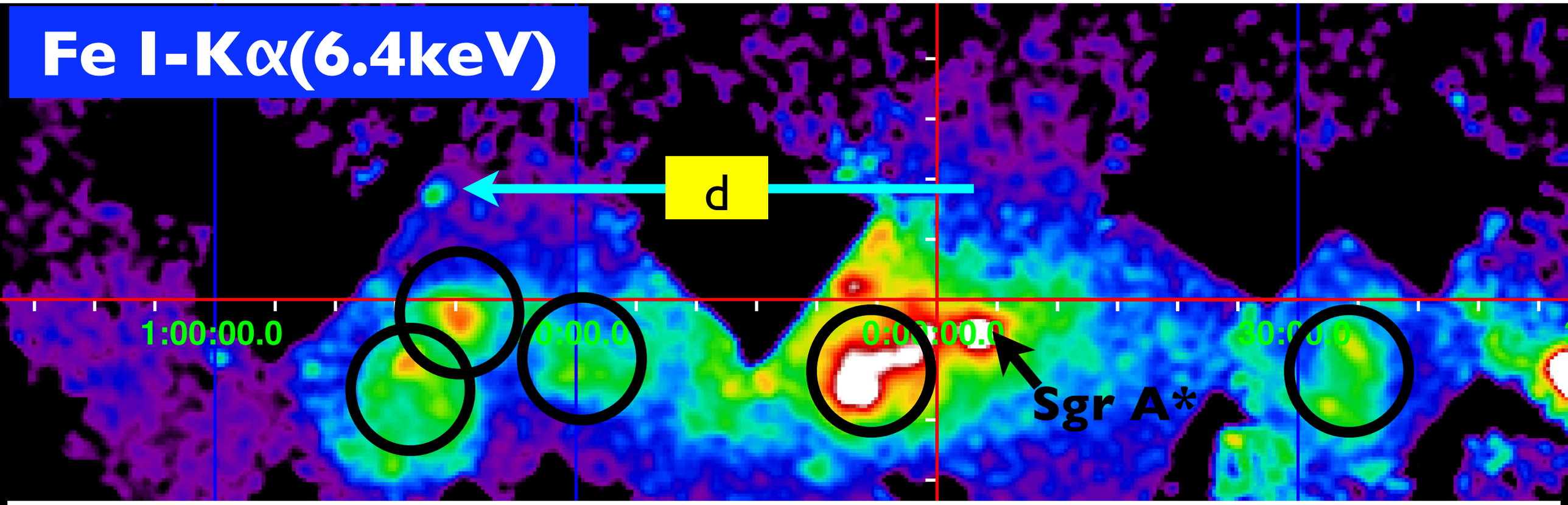
Past Activity of Sgr A*

Mini-Starburst

Rich phenomena due to the interaction among SMBH, ISM, SNR, SFR, Magnetic field, CRs ...

(Single white papre can not handle all of them ...)

XRN - Echo of the Past Activity of Sgr A*



Echo → we can observe the past luminosity and spectrum of Sgr A*.

- L(Sgr A*) ∝ L(XRN) x d ^ 2
- Distance "d" between XRN and Sgr A*
  → Look back time of echo

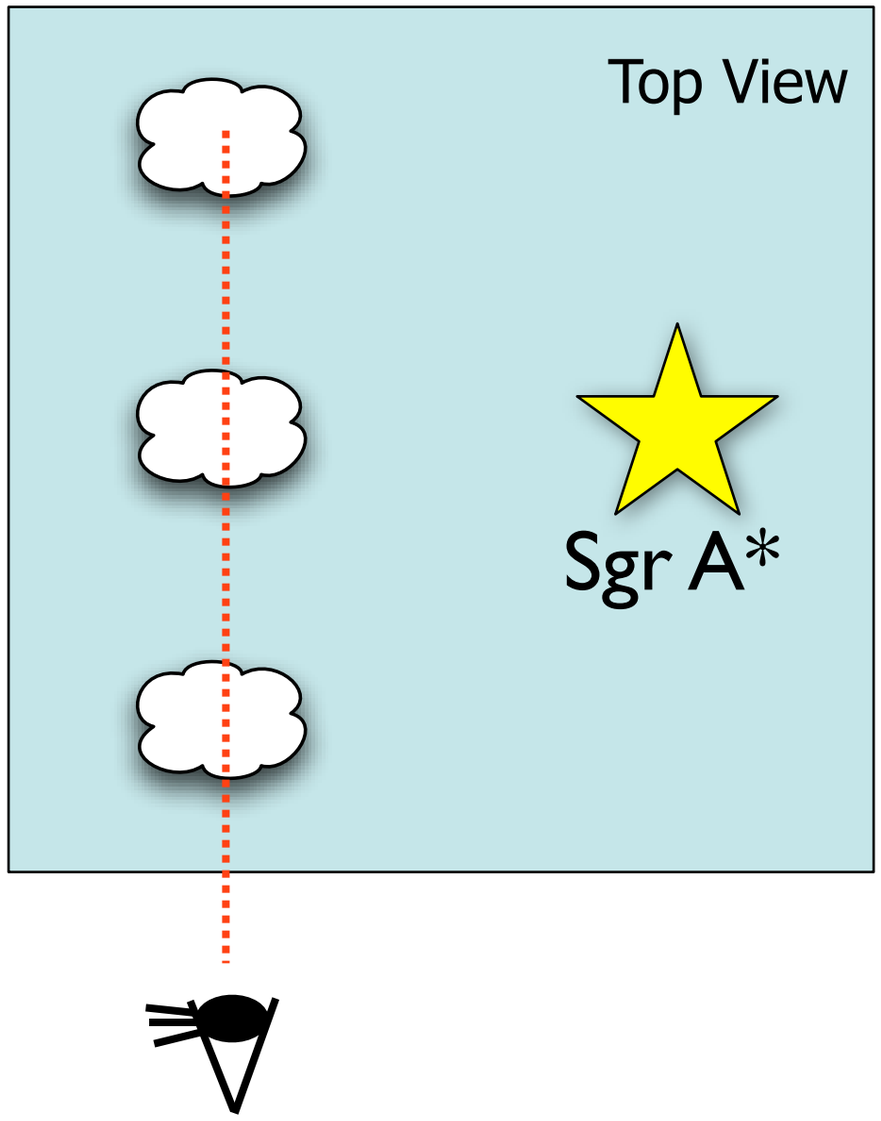
→ Collecting XRNe
Long Term (~1000yr)
Light Curve of Sgr A*

Very Unique Study

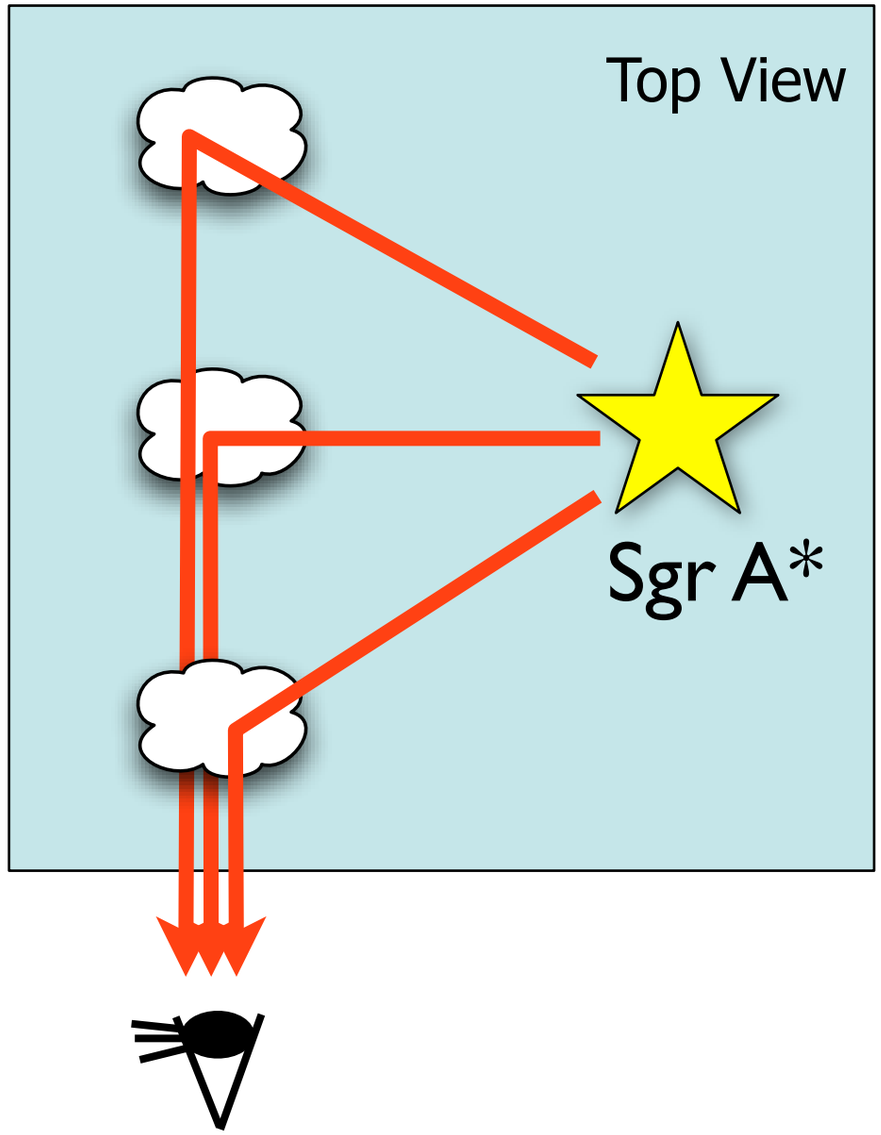
Only Sgr A* allows us to access such a long-term history.

Easier said than done 言うが易し，行うが難し

In order to obtain an accurate light curve...



- Need to identify the XRN from the three MCs overlapping each other in the same line of sight.
- Need to obtain the distance of the identified MC along the line of sight.



Radio observation of molecular line

moleculre CS line

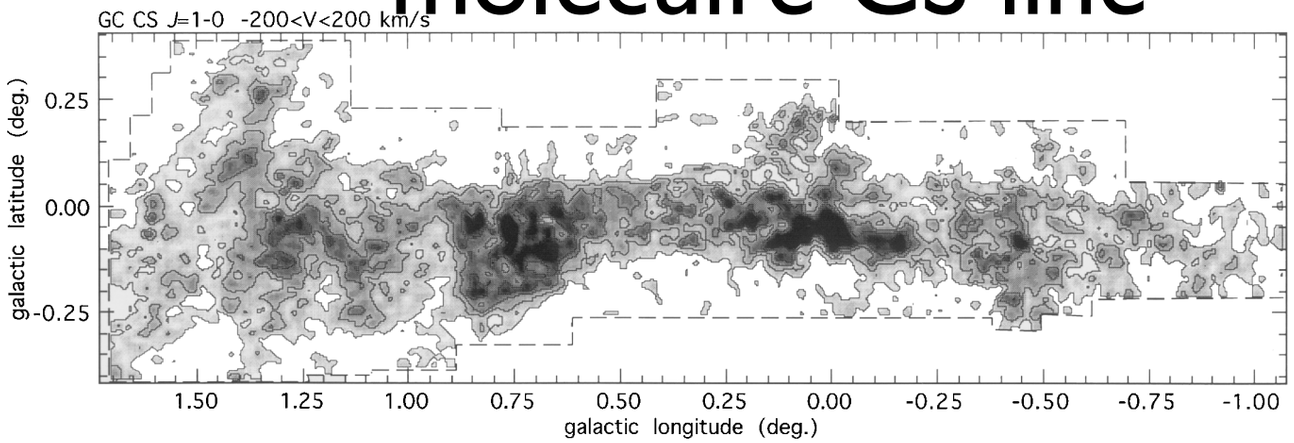


FIG. 2*a*

Position-Velocity diagram

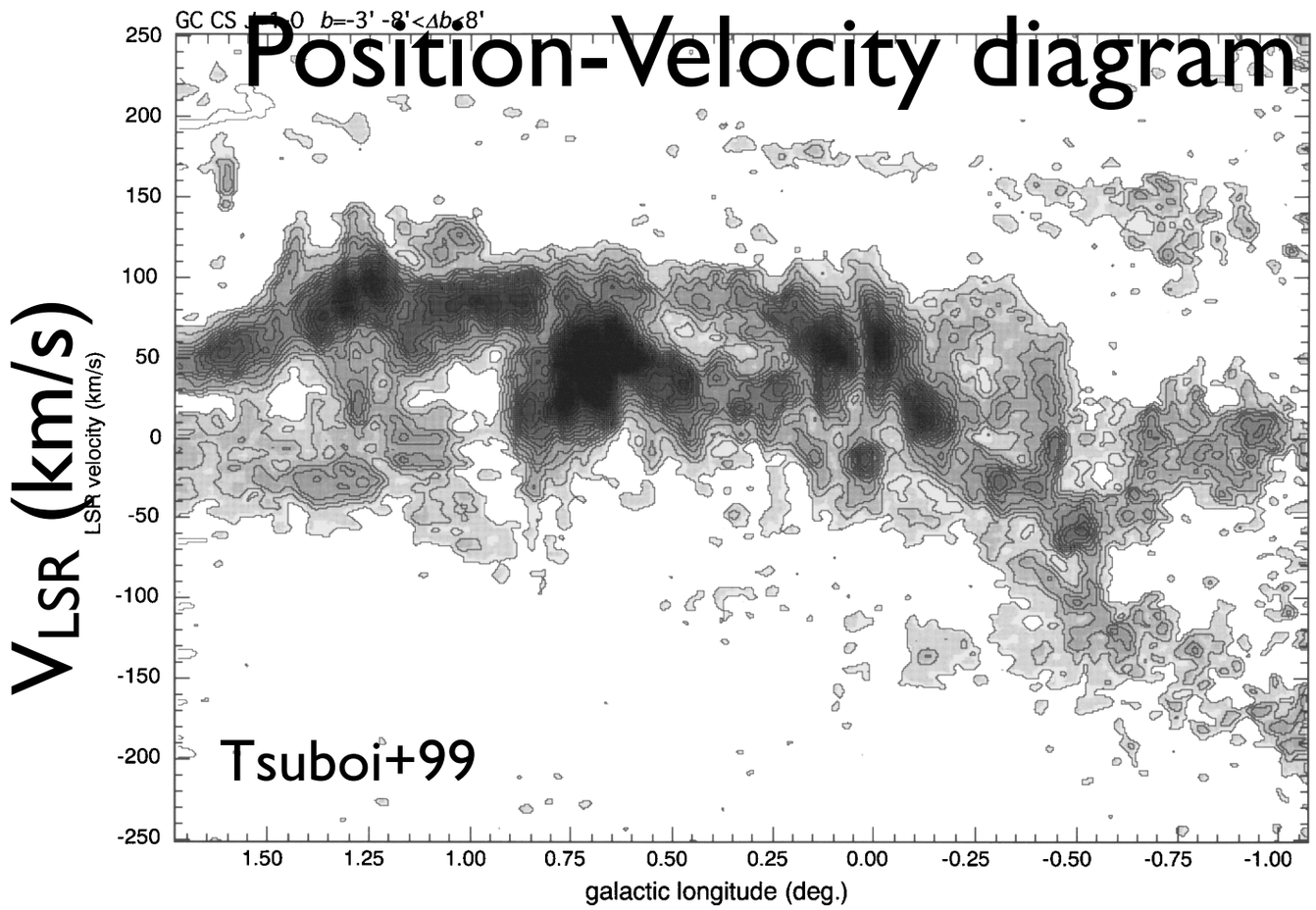


FIG. 2*b*

FIG. 2.—(*a*) Velocity-integrated CS $J = 1$–0 emission in the Galactic center region. The data have been numerically convolved with a 60″ circular Gaussian beam. The velocity integrated range is from -200 to 200 km s^{-1}. Contour interval and first contour level are both 35.7 K km s^{-1} in T_{MB}. The rms noise is 6.3 K km s^{-1}. (*b*) Longitude-velocity diagram averaged in the range of $-11' \leq b \leq 5'$ (Note that the Galactic latitude of Sgr A* is located at $b = -3'$) in the Galactic center region. Contour interval and first contour level are both 0.55 K in T_{MB}. The rms noise is 0.27 K km s^{-1}.

Face-on view

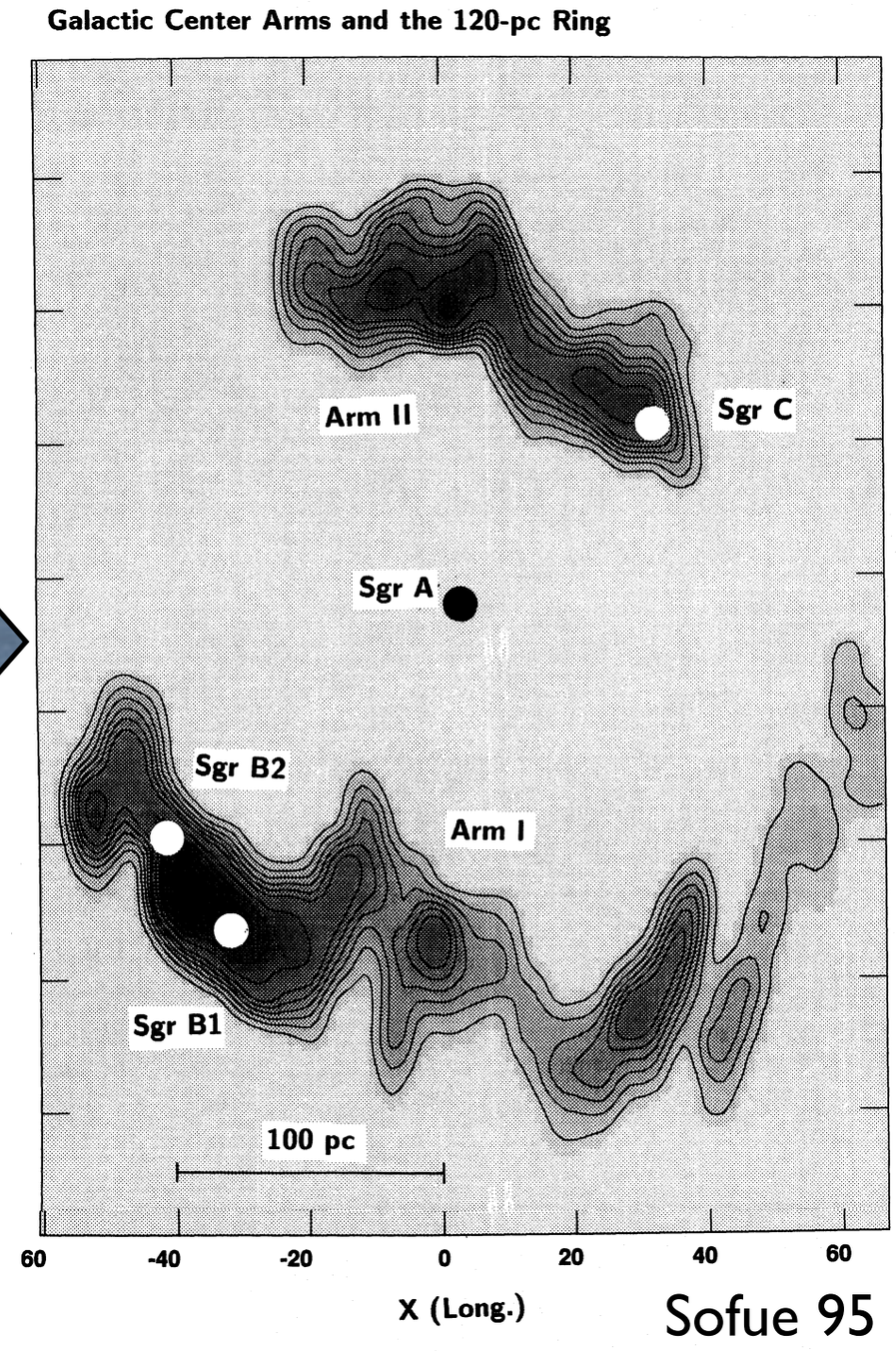
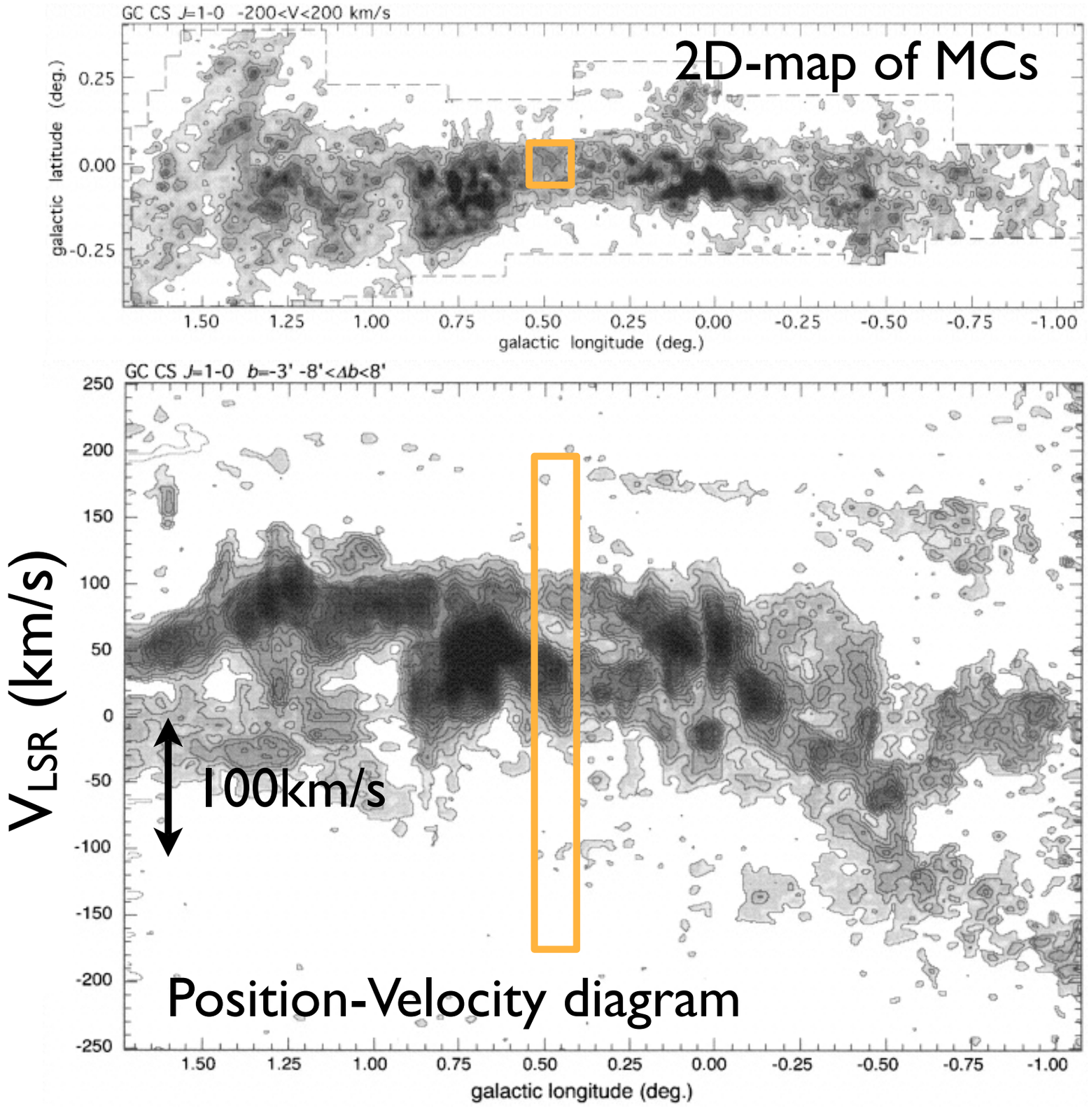


Fig. 10. Possible deconvolution of the (l, V) diagrams for Galactic Center Arms I and II into a spatial distribution as projected on the galactic plane. The contour interval is 0.25 starting at 0.1 in an arbitrary unit. A is assumed to be at the center.

Note: The X-ray absorption technique allows us to access the face-on view (Ryu+09), which is independent from radio.

Identifying XRN with MC

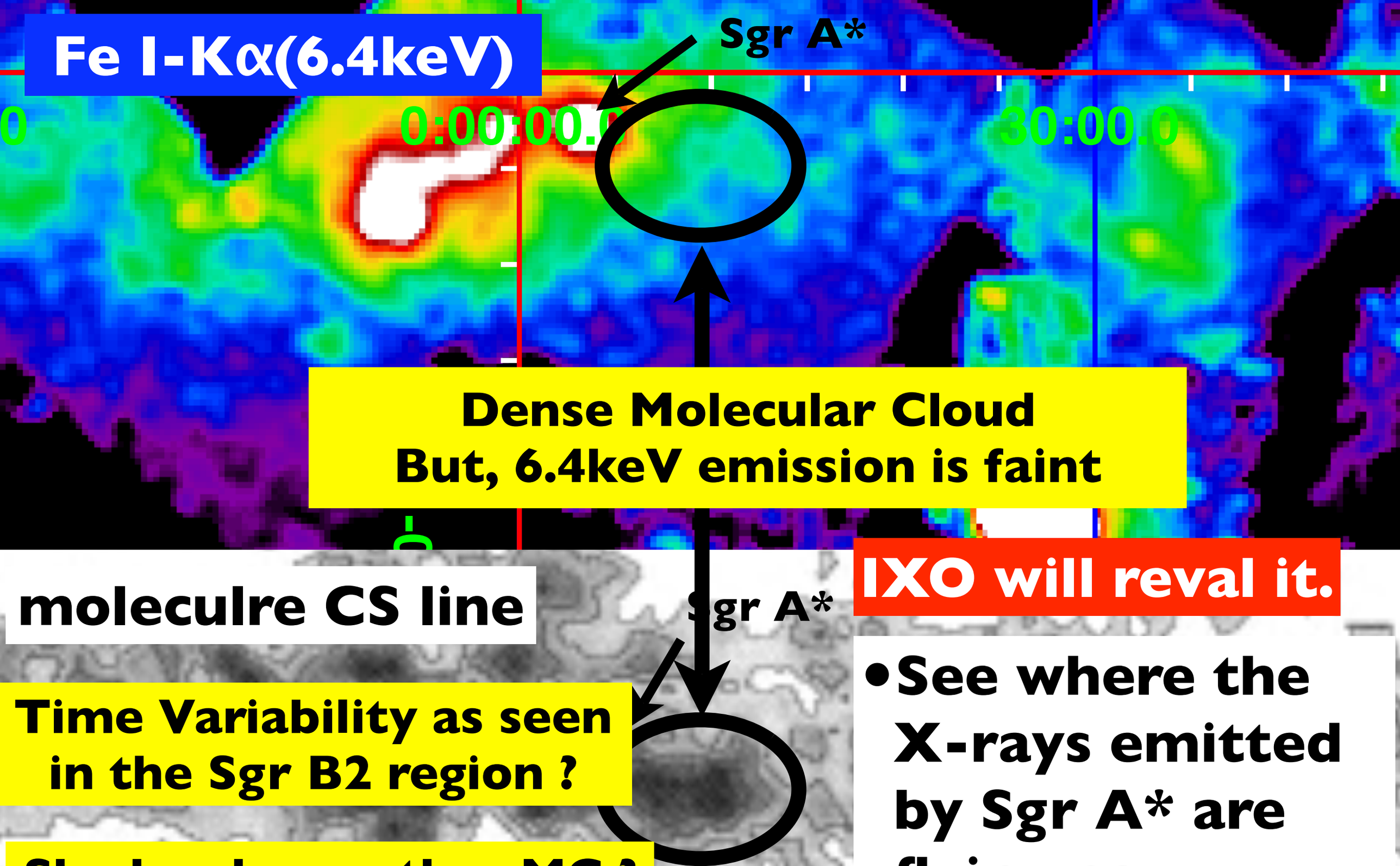


XMS
line of sight velocity of
6.4keV line of XRN

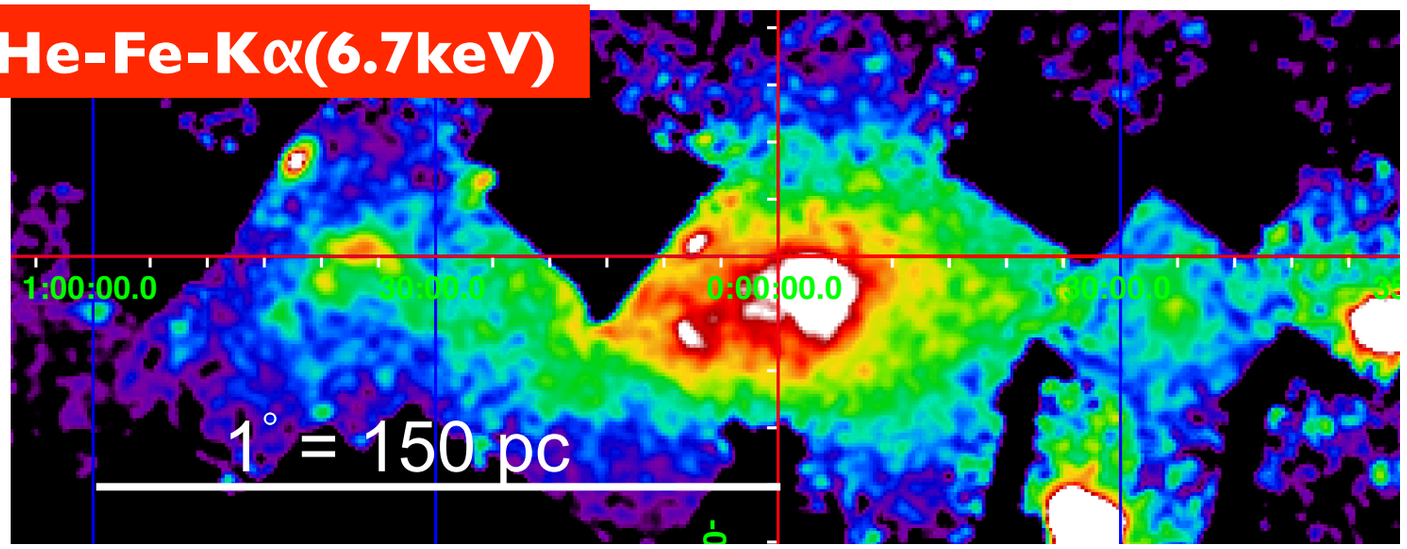
Δv ~ 100km/s is
necessary.
Energy Resolution of
ΔE ~ 2.5eV @ 6keV
is essential.

Identify the XRN
with the MC.
Face-on fiew
→ 3D Position of XRN

Radio observation
line of sight velocity of
molecular line

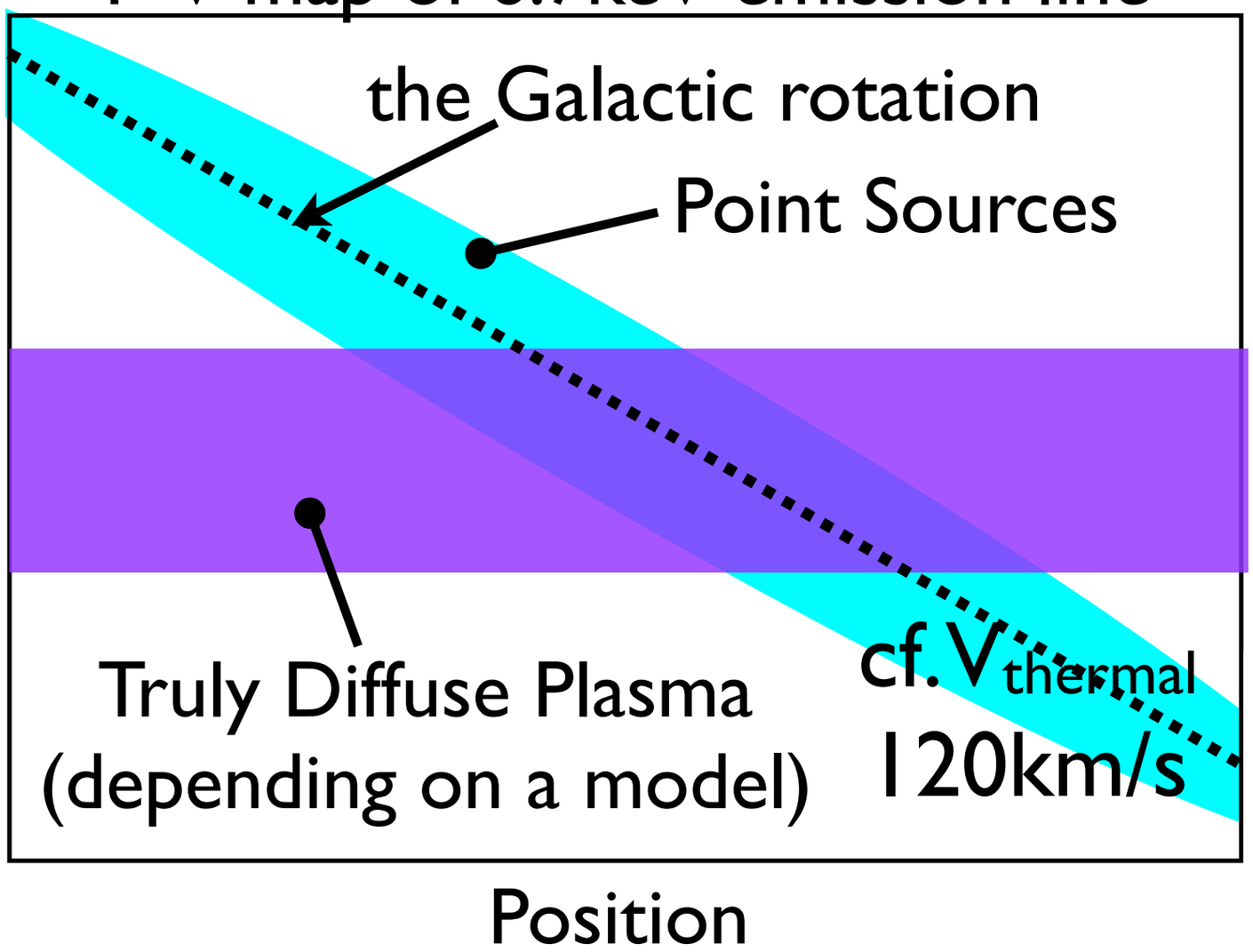

Fe I-Kα(6.4keV)
Sgr A*
0:00:00.0
30:00.0
Dense Molecular Cloud
But, 6.4keV emission is faint
moleculre CS line
Sgr A*
IXO will reval it.
Time Variability as seen in the Sgr B2 region ?
Shadow by another MC ?
Beaming of Sgr A* ?
•See where the X-rays emitted by Sgr A* are flying now.
•Predict what happens next.

6.7keV He-Fe-Kα emission line

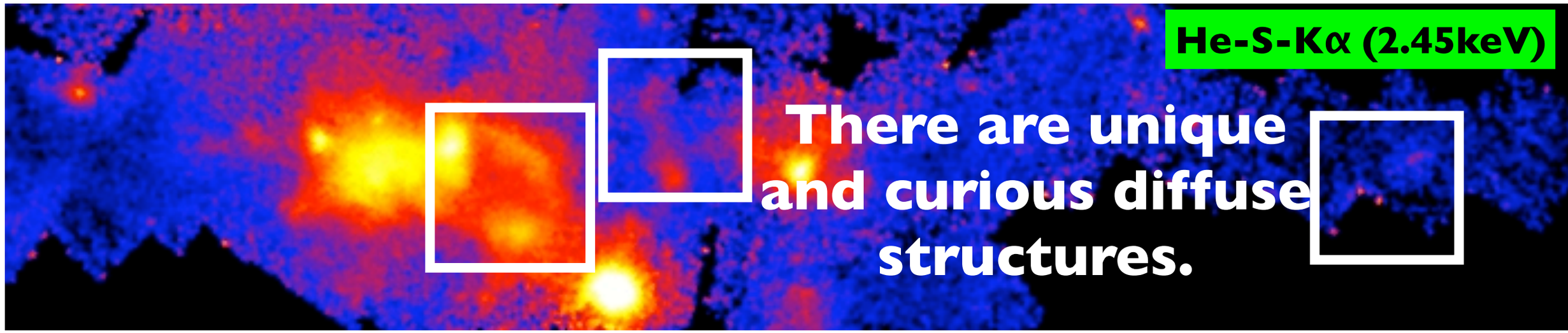


- ΔE=2.5eV (100km/s) is also important for the study of the plasma in the GC region.
- Make P-V map of 6.7keV emission line.
- See if it is on the Galactic rotation or not.
- P-V map of point sources is expected on the Galactic rotation.
- If observed P-V map is not on the Galactic rotation, truly diffuse plasma.
- Explore the dynamics of the diffuse plasma.
  Eexpanding ? Outflowing ?

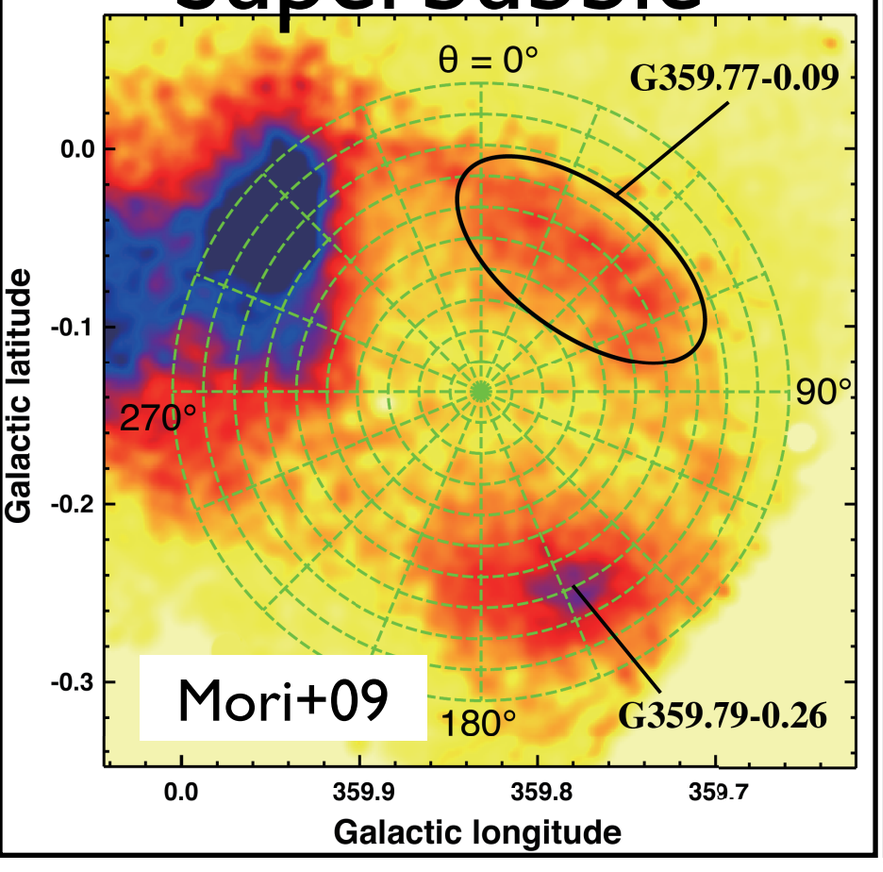
P-V map of 6.7keV emission line



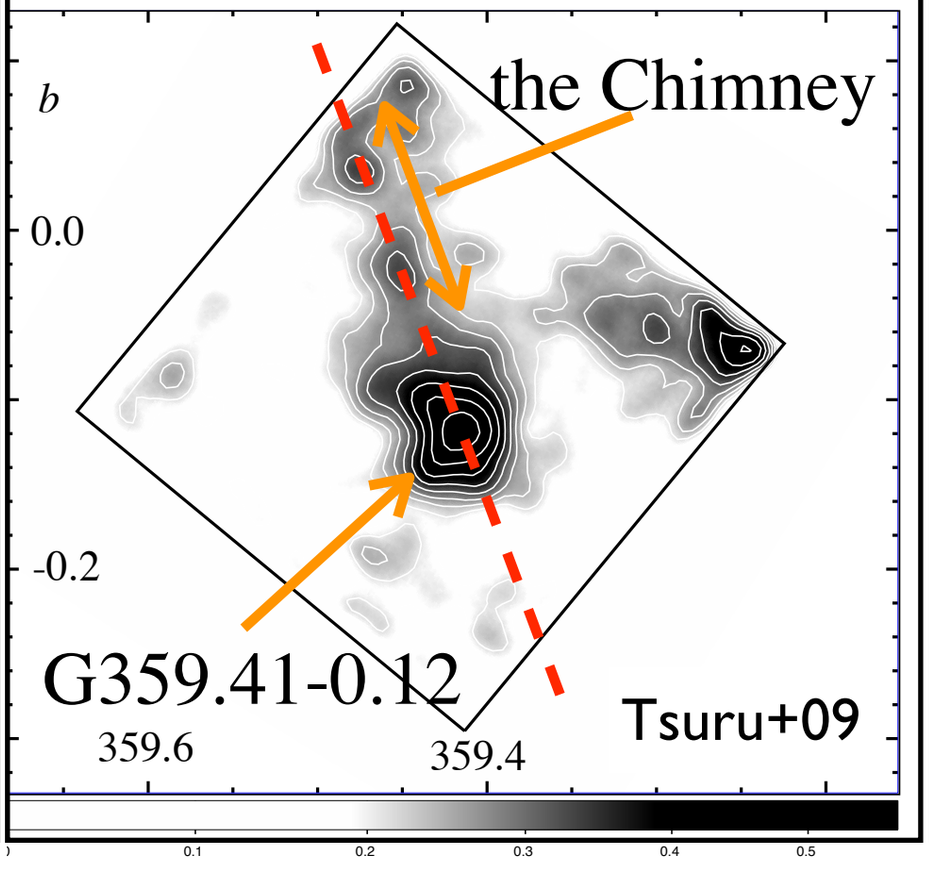
2.45keV He-S-Kα emission line



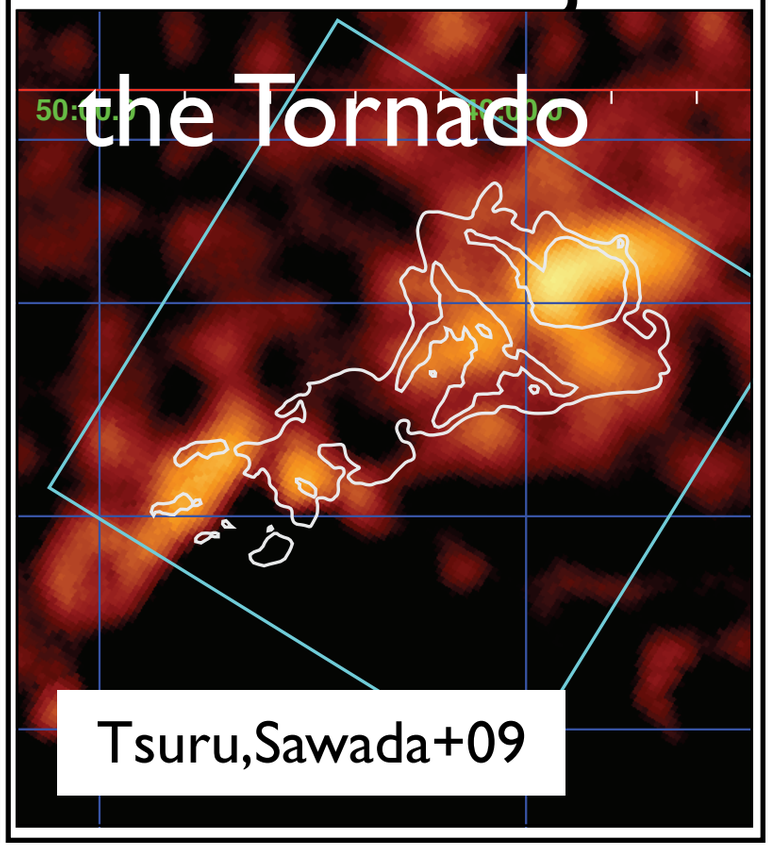
Superbubble



SNR with an outflow

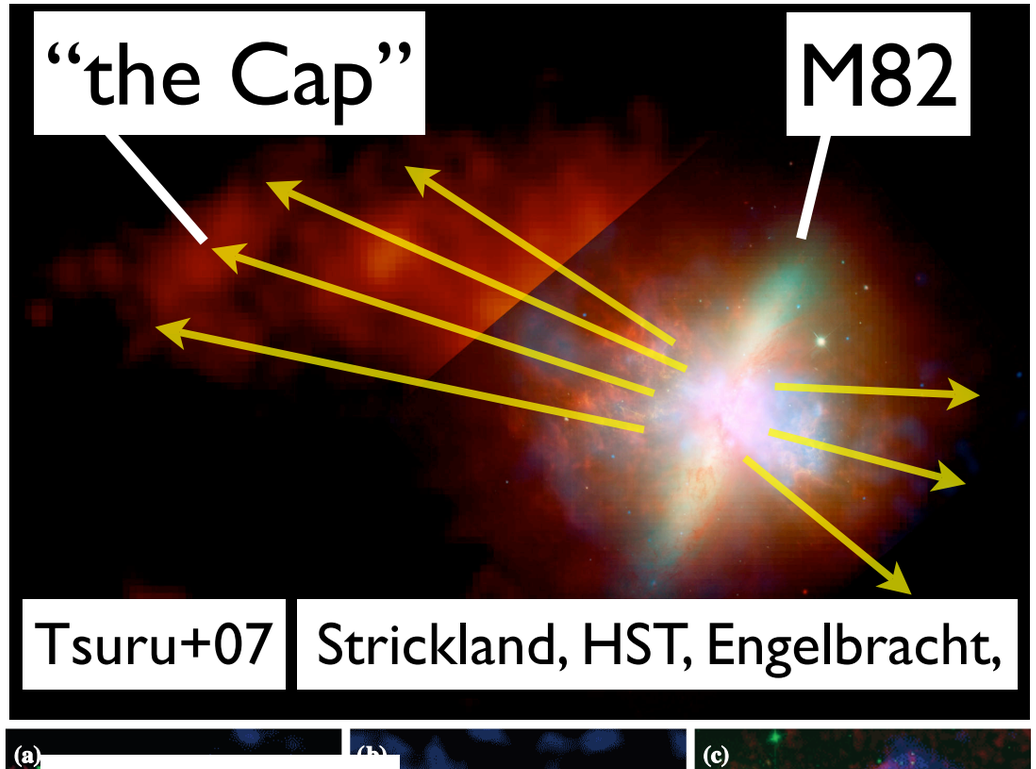


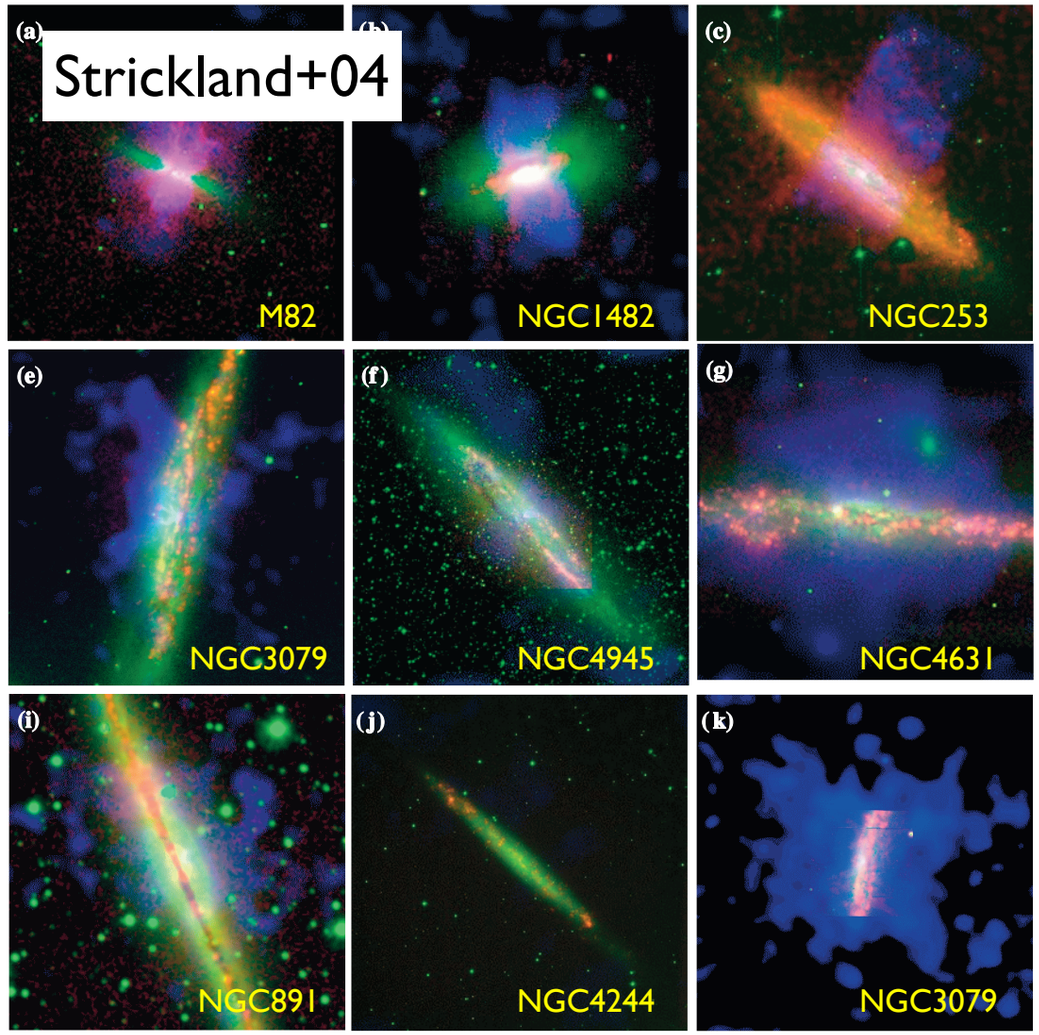
Unusual Object



X-ray P-V map will make the search much easier.

Outflow from a starburst galaxy - "Superwind"





- Plasma with kT>1keV created by a starburst activity in the central region can escape the host galaxy. It forms a galactic outflow, "Superwind".
- The X-ray emitting phase of a superwind contains the majority of its energy and newly-synthesized metals, and given its high specific energy.
- Superwinds are ubiquitous in the galaxies forming stars in a high rate and an early galaxy.

Key Question:
What is the contribution of mass, metals and energy from starburst galaxies to the Intergalactic Medium ?

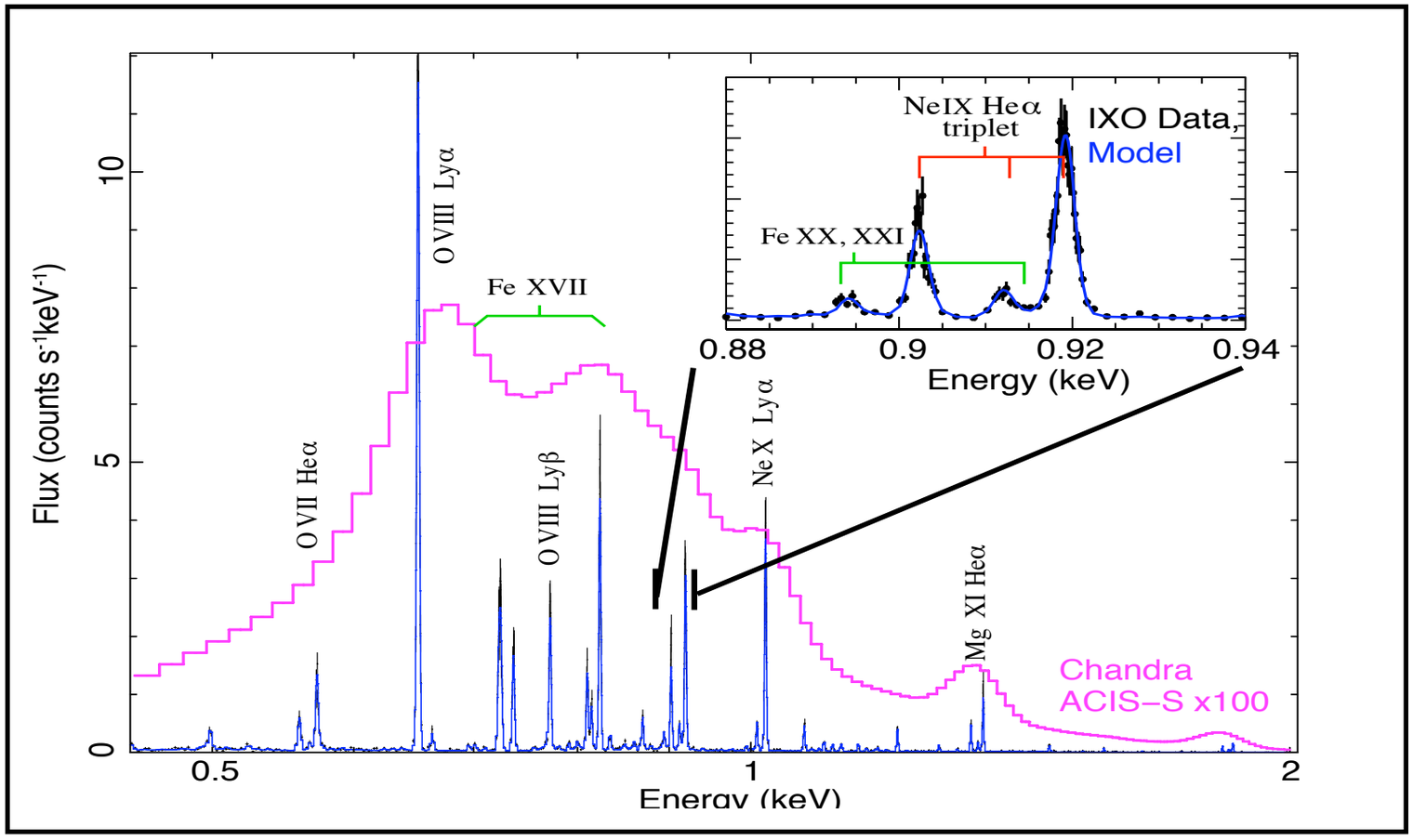
IXO observation of superwind

- IXO reveals the mass, metals and energy from starburst galaxies injected into the Intergalactic Medium.
- IXO can observe a sample of ~35 local starbursts at D<200Mpc, covering a suitably broad range of galaxy mass (10^{8}~$10^{11.5}M_{@}$).

Small region of the superwind of M82

XMS of IXO compared with CCD

Adopted from the RFI.



- Note that the Suzaku spectrum of the Cap of M82 shows a hint of existance of charge exchange process (Tsuru+06). We would be able to investigate the cold phase of IGM.

Summary
(Key Question)

the Galactic center region

What happend and will happen in the Galaxy where we live ?

What is the origin of the activities of the Galactic center region ?

Starburst galaxy

What is the contribution of mass, metals and energy from starburst galaxies to the Intergalactic Medium ?